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WILLS'S TABLES

FOR

QUALITATIVE CHEMICAL ANALYSIS.

TRANSLATED FROM THE SECOND GERMAN EDITION,

FOR THE

USE OF STUDENTS.

BY WILLIAM L. FABER,

LATE OF THE UNIVERSITIES OF FREIBERG, MARBURG, AND GIESSEN.

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TABLES

FOR

QUALITATIVE CHEMICAL ANALYSIS.

BY

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TRANSLATED FROM THE SECOND GERMAN EDITION FOR THE USE OF STUDENTS

IN THE

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362776
13. 2. 39.

PHILADELPHIA:

A. HART, LATE CAREY AND HART.

1852.

PHILADELPHIA:

T. K. AND P. G. COLLINS, PRINTERS.

CONTENTS OF THE TABLES.

TABLE I.—*General Preliminary Examination.*—Behavior of inorganic substances before the blowpipe.

TABLE II.—*Preliminary Examination of Metallic Oxides.*—Their behavior before the blowpipe with microcosmic salt, borax, and soda.

TABLE III.—Rendering insoluble substances soluble.

TABLE IV.—*Systematic Qualitative Analysis of Bases.*—A. Behavior of solutions of the metallic oxides to chlorohydric acid, sulph-hydric acid, sulphide of ammonium, and carbonate of ammonia, used successively.

TABLE V.—B. Treatment of the precipitate by sulph-hydric acid.

TABLE VI.—C. Treatment of the precipitate by sulphide of ammonium.

TABLE VII.—D. Treatment of the precipitate by carbonate of ammonia (carbonates of the alkaline earths).

TABLE VIII.—E. Treatment of the liquid which is precipitated neither by sulph-hydric acid, nor by sulphide of ammonium, nor by carbonate of ammonia (magnesia and the alkalis).

TABLE IX.—*Preliminary Examination of Acids.*—Behavior of the most important acids, or haloids, on treating their combinations with concentrated sulphuric acid.

TABLE X.—Behavior of the most important acids to reagents: chlorohydric or nitric acid, chloride of barium, chloride of calcium, and sulphate of magnesia.

TABLE XI.—Behavior of the most important acids to perchloride of iron, nitrate of silver, and solution of indigo.

TABLE XII.—Equivalents of the simple substances, II = 1.

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TABLE I.—GENERAL PRI

BEHAVIOR OF INORGANIC SUB

1. Very volatile when heated on charcoal or platinum foil:	All compounds of *ammonia* and of *mercury;* some of *arseni* are decomposed, the greater part of them blackening
2. Fusible without volatilizing or changing color:	Most of the salts of the *alkalies* and several of the *alkaline* flame. Several *silicates*, such as the zeolites. Of r copper, and gold with more difficulty; and the forme
3. Infusible, or nearly so, without changing color:	The *earths*, *alkaline earths*, and their salts; they phosphore and most of its compounds. Metallic iron, nickel, co
4. Assuming a darker color when heated:	Many *metallic oxides* and their *salts;* such as oxides of *zinc* oxides of *lead*, *bismuth*, etc., brown.
5. Coloring the outer flame of the blowpipe when heated on platinum wire:	Salts of *potassa*, violet; of *soda* (or a mixture of the three momentarily, salts of *baryta*, slightly yellowish-green
6. Producing, when moistened with solution of cobalt, and strongly ignited on charcoal:	Blue glass: *Phosphates*, *borates*, and *silicates* of the alkalies. — Infusible blue mass: *Alumina* and many of i compounds; *phosphates* the earths; some *silicates*.
7. Producing, when heated with soda (or a mixture of soda and cyanide of potassium), on charcoal:	Odor of garlic: All compounds of *arsenic*. — Hepar:* All compounds of *sulphur* (selenium, tellurium). — Metallic g: *Tin*, *Silver*, *Copper*, *Gold*, shinin ducti scale
	* The substance, on being moistened, blackens silver, and
8. Producing, when heated in a tube open at both ends, and held in a sloping position:	Odorous gases: Metallic *sulphides*, of burning sulphur. Metallic *selenides*, of rotten radishes. Metallic *arseniurets*, of garlic. Some *ammoniacal compounds*, of ammonia. — Metallic coa: Several *arsenium* compounds of m (especially on a of soda).
9. Deflagrating on charcoal:	Nitrates, chlorates, perchlorates, iodates, bromates, &c.
10. Being reduced, and coloring the liquid, when in contact with zinc and chlorohydric acid:	Violet: *Titanic acid.* — Blue, changing to green and black: *Molybdic acid.* — B

MINARY EXAMINATION.

ICES BEFORE THE BLOWPIPE.

lphur and its *acids; water.* *Carbon* burns when ignited in the air; and all *organic* substances st from the separation of carbon.

s; they color turmeric paper brown after being exposed to a high temperature in the reducing ne metals, antimony, lead, cadmium, tellurium, bismuth, and zinc are easily fusible; silver, uls give deposits of oxides. (See 7 below.)

ith a white light when heated, and the earths show no alkaline reaction after ignition. *Silica* molybdenum, tungsten, platinum, palladium, and iridium are infusible.

tin, titanic and *antimonic* acids, all yellow; zinc phosphorescing with a yellowish-green light;

es), yellow; of *lithia*, crimson. When moistened with chlorohydric acid, and showing a color *strontia*, dark red; of *lime*, dark orange; of *copper*, bluish-green.

Green:	Bluish-green:	Flesh-red:	Gray or grayish-black:
Oxide of zinc.	*Oxide of tin.*	*Magnesia.*	*Strontia, lime, glucina,* and most of the other *earths.*

without sublimate:		Metallic globule with sublimate:		Sublimate without metal:	
ckel, Tungsten, balt, Platinum, n, Iridium, lybdenum,	gray infusible powder.	*Antimony,*	white.	*Zinc,*	white.
		Lead,	yellow.	*Cadmium,*	dark yellow.
		Bismuth,	brownish-yellow.	*Tellurium,*	white.

ops with acids sulphuretted (seleniuretted or telluretted) hydrogen.

White sublimate:	Fused sublimate:	Drops of water:
Arseniurets, crystalline.	*Metallic polysulphides,* brownish-yellow.	*All hydrates.* (More distinct in a tube closed at one end, or a matrass.)
Antimoniurets } fusible.	*Seleniurets* (and selenium), dark red.	
Tellurets } fusible.	Sulphide of arsenic.	
Sulphide of lead (galena).		
Some *salts of ammonia.*		

hanging to copper-red:	Blue, changing to brown:	Green:
Tungstic acid.	*Columbic acid.*	*Chromic acid.*
	Niobic "	
	Pelopic "	

TABLE II.—PRELIMINARY EX

BEHAVIOR OF METALLIC OXIDES BEFORE THE BL

COLOR OF THE BEAD.	WITH MICROCOSMIC SALT:	
	IN THE OXIDIZING FLAME:	IN THE REDUCING FLAME:
Green:	Oxide of chromium, " copper, " uranium.	Oxide of chromium, " uranium, " iron, Molybdic acid, Vanadic "
Blue:	Oxide of cobalt.	Oxide of cobalt, Tungstic acid.
Violet:		Titanic acid, Niobic "
Amethyst:	Protoxide of manganese.	
Brown:		Oxide of copper, Pelopic acid.
Red: (Brownish-red or blood-red.)	Oxide of nickel, " iron (while hot), " cerium.	Oxide of nickel, Tungstic acid } in presence of Titanic " } iron.
Yellow:	Vanadic acid, Oxide of bismuth, " silver.	Columbic acid.
Gray: (From particles of reduced metal.)		Oxide of bismuth, " lead, " silver, Telluric acid.
Colorless: (See the note.)	Molybdic acid, Tungstic " Titanic " Oxide of antimony.	Oxide of cerium, " manganese.
Skeleton of Silica:	Silicic acid.	Silicic acid.
With Soda: Transparent bead (on platinum wire):	Silicic acid, and several silicates containing but little base, dis	
With Soda: On platinum foil: Bluish-green mass:	All compounds of manganese, in the oxidizing flame, especial	
With Soda: On platinum foil: Clear fused mass:	Only the alkalies or their salts. The fused substance is entire	
With Soda: On platinum foil: Opaque, fused mass.	The alkaline earths and earths, as well as most oxides of the	

NATION OF METALLIC OXIDES.

IPE WITH MICROCOSMIC SALT, BORAX, AND SODA.

WITH BORAX:		NOTE.
N THE OXIDIZING FLAME:	IN THE REDUCING FLAME:	
de of chromium, " copper.	Oxide of chromium, " uranium, " iron, Vanadic acid.	Colorless beads are produced with microcosmic salt and with borax, in the oxidizing as well as the reducing flame, by the alkaline earths and the earths proper. The beads, when saturated with them, generally become opaque and milk-white, or like enamel. Alumina always produces a transparent bead with microcosmic salt. The colors of the beads differ in intensity according to the quantity of oxide dissolved in them. The color is, therefore, determined with certainty by gradually saturating the bead with the substance in form of a fine powder; the bead being situated at the end of a platinum wire, made like a crook, or, in some cases, when the reducing flame is employed, on a piece of charcoal.
de of cobalt.	Oxide of cobalt.	
	Titanic acid.	
toxide of manganese.		
	Oxide of copper. Molybdic acid.	
de of nickel, " iron, " cerium.	Tungstic acid.	
nadic acid, de of lead, " uranium.	Tungstic acid.	
	Oxide of nickel, " bismuth, " silver, " antimony, Telluric acid.	
ybdic acid, gstic " nic " de of bismuth, " antimony, " tin.	Oxide of cerium, " manganese.	
cic acid dissolves slowly in borax.		

with intumescence in fused soda.

en taken in small quantity, and assisted by saltpetre. Chromium yields a yellow mass.

uble in water after cooling.

proper. The fused substance is not entirely soluble in water after cooling.

TABLE III.—RENDERING IN

When a compound remains undissolved after being digested successively with *water*, *dilute* a or acted on, by the acids in such a manner as, from its behavior, to allow positive conclusions a cesses, before its constituents can be tested for in the humid way. The process employed in eve ducted with great care. If, in this manner, no *decisive* indication of the necessary treatment of of a fine powder, with four times its weight of carbonated alkali, and the fused substance treate crucibles must *never* be employed for fusion when the substance contains *arsenic*, or any *easily-re*

1. *Sulphates.*	2. *Silica and Silicates.*	3. *Fluoride*
They give *hepar* on charcoal with soda; sulphates of baryta, strontia, and lime *without* a metallic bead, and sulphate of lead *with* a metallic bead. Sulphate of lime is somewhat soluble in water. Solution is effected by boiling with a concentrated solution of carbonated alkali, and filtering (sulphate of baryta will not dissolve perfectly without fusion). The acid will be found in the filtrate, and the base in the residue.	They give a *skeleton of silica* with microcosmic salt. Those silicates which will not decompose with chlorohydric acid, are fused with three or four parts of carbonated alkali (or hydrate of baryta), and treated with *chlorohydric acid*, after which the liquid must be evaporated to dryness, to render the silica insoluble. Or they may be treated with fluohydric acid.	They develo concentrated s They are re sion with fou alkali (perfectl silica), and boi
6. *Oxide of Tin* and *Antimonic Acid.*	7. *Titanic, Tungstic, Niobic, Pelopic,* and *Columbic Acids.*	8. *Chlorides* (ch of silve
They give ductile or brittle metallic globules with soda on charcoal. They will dissolve in acids after being fused with three or four parts of carbonated alkali.	They give with microcosmic salt a *blue*, *violet*, or (in case iron is present) a *blood-red* bead, and show a *distinctive color* with zinc and chlorohydric acid. They are rendered soluble by fusion with four parts bisulphate of potassa (or with carbonated alkali).	*Chloride, iod silver* are fusib like substance; bule of silver w They are dec dilute sulphuric with caustic li kali, the meta *Sulphide of mol* into molybdic a the air, after wh the alkalies.

UBLE SUBSTANCES SOLUBLE.

ncentrated chlorohydric acid, *nitric* and *nitro-muriatic* acids, and at the same time is not decomposed, he nature of the insoluble substance, the latter must then be prepared for solution by certain pro- gle case being determined by the results of the preliminary examination, the latter must be con- soluble compound, according to the table below, can be found, it is always to be fused, in the form . water; after which, the residue, being well washed, is dissolved in chlorohydric acid. Platinum *e metal* (antimony, tin, lead, bismuth, etc.).

r spar, etc.). *hydric acid* with ric acid. l soluble by fu- rts carbonated an addition of with water.	4. *Alumina* or *Aluminates*. They give a *blue* infusible mass when heated with solution of cobalt. Solution is effected by fusion with three or four parts of bisulphate (or carbonate) of potassa or soda, and treatment with water or chlorohydric acid.	5. *Oxide of Chrome* (chromic iron). They give green glasses with microcosmic salt and borax in either flame. They are fused with bisulphate of potassa, or with carbonated alkali and saltpetre. Chromic iron requires successive treatment by both methods; and it is first fused with bisulphate of potassa.
, bromide, iodide *lphides*. nd *bromide of* rming a horn- hey give a glo- da. ed by zinc and or by ignition carbonated al- ng separated. *m* is converted calcination in is soluble in	9. *Reguline Metal*. The insoluble substance has a metallic lustre, or is black, pulverulent, and unchangeable by heat. (Iridosmin or residues of platinum ores.) It is rendered soluble by being heated to redness, mixed with common salt in a current of chlorine; or by fusion with potassa and chlorate of potassa.	10. *Carbon*. The insoluble substance is black (except colorless diamonds), and disappears on the application of strong heat in a platinum crucible, or before the blowpipe. It deflagrates when fused with saltpetre, carbonate of potassa being formed.

TABLE IV.—SYSTEMATIC QUA

A. BEHAVIOR OF SOLUTIONS OF METALLIC OXIDES TO CHLOROHYDRIC ACID, SULPH-HY

CHLOROHYDRIC ACID.	SULPH-HYDRIC ACID.[3]		
Oxides which are precipitated as chlorides by *chlorohydric acid* from a neutral or acid solution:[1]	Oxides which are partially *reduced* in an acid solution, while *sulphur* is precipitated:[2]	Oxides which are precipitated by *sulph-hydric acid* from a solution *acidulated* with chlorohydric or nitric acid. The sulphides are:	
		Soluble in Sulphide of Ammonium:	Insoluble in Sulphide of Ammonium.
Oxide of lead; white, crystalline; soluble in much water.	Peroxide of iron; the liquid is dissolved and contains protoxide.	Oxide of antimony, Antimonic acid, } orange.	Suboxide of mercury, Protoxide of mercury, Oxide of silver, " lead, " copper, " bismuth, } black.[4]
Oxide of silver; white, caseous; soluble in ammonia.	Chromic acid; the liquid turns green, and contains oxide of chrome.	Arsenious acid, Arsenic " } yellow.	" cadmium, yellow.
Suboxide of mercury; a white powder; it is blackened by ammonia.		Oxide of tin, brown, Stannic acid, yellow.	" palladium, " osmium, " rhodium, " ruthenium, } black or brown.
		Oxide of gold, " platinum, " iridium, } brownish-black.	
		" molybdenum, brown.	
		Selenic acid, orange. Telluric acid, black.	

[1] In an *alkaline* solution, chlorohydric acid (and also nitric acid) may effect a precipitate when the solution contains:
Silicic acid,
Boracic acid,
Antimonic acid,
Tungstic acid,
Molybdic acid,
and several oxides, cyanides, and sulphides, which are soluble in the alkalies.

[2] A precipitation of sulphur may also be effected by the presence of free chlorine, bromine, iodine, and sulphurous, nitrous, hypochlorous, chloric, bromic, and iodic acids, etc.

[3] The oxides of tungsten and vanadium are only then precipitated as sulphides, when their solution, containing sulphide of ammonium, is decomposed by an acid. The solution of the protosulphide of tin, Sn S, in sulphide of ammonium is precipitated yellow by acids, as bisulphide, $Sn S_2$.

[4] Protoxide of mercury is precipitated white by a very small quantity of sulph-hydric acid; and the more sulph-hydric acid is employed, the darker the precipitate grows, passing to black through all the shades of yellow, orange, red, and brown.

LTATIVE ANALYSIS OF BASES.

E ACID, SULPHIDE OF AMMONIUM, AND CARBONATE OF AMMONIA, USED SUCCESSIVELY.

SULPHIDE OF AMMONIUM.			CARBONATE OF AMMONIA.	
xides which are precipitated from a *neutral* solution by *sulphide of ammonium*, in presence of chloride of ammonium.			Oxides which are precipitated neither by sulphhydric acid nor by sulphide of ammonium. *Carbonate of ammonia*, in presence of chloride of ammonium	
as sulphides:[5]	as oxides: ammonia precipitates them also.	as salts:[6] ammonia precipitates them also.	*precipitates white:*[7]	*leaves in solution:*
ide of nickel, cobalt, oxide of iron, oxide of iron, } black. ides of manium, } brownish black. oxide of manganese, sh-colored. ide of zinc, white.	a. *Soluble in Potassa:* Alumina, [Glucina], } colorless. Oxide of chrome, green. Columbic acid, Niobic " Pelopic " } white. b. *Insoluble in Potassa:* [Oxide of cerium, " lanthanum], " didymium, [Yttria], [Erbia], [Terbia], [Zirconia], [Thoria], [Titanic acid], } colorless or white.	a. *In presence of Phosphoric Acid:* Magnesia, crystalline. b. *In presence of Phosphoric or Oxalic Acid:* Lime, Strontia, Baryta, } white.	Baryta. Strontia. Lime.	a. *Phosphate of soda precipitates:* Magnesia, crystalline. b. *Phosphate of soda does not precipitate:* Potassa, Soda, [Lithia], Ammonia.
Sulphide of zinc is inble in acetic acid; sulde of cobalt and sulde of nickel are with ficulty soluble in dilute drohydric acid as well as acetic acid; and sulde of nickel is slightly uble in yellow (ammoical) sulphide of ammoium, imparting to it a wn color.		[6] All the salts mentioned are insoluble in potassa; and while the phosphates of the alkaline earths are soluble in acetic acid, oxalate of lime is insoluble in that acid.	[7] The precipitation is more perfect in presence of ammonia.	

TABLE V.—SYSTEMATIC QU

B. TREATMENT OF THE PRECIPITATE BY SULPH-HYDRIC AC

A part of the precipitate, after being well washed, is digested with sulphide of ammoniu *entirely*, or *partly*, or *not at all*. Only when partial solution ensues, the remaining portion of th dric acid to the filtrate of the insoluble portion, when a *colored* precipitate shows the presence of

A. *Portion Soluble in Sulphide of Ammonium.*—The sulphide which chlorohydric acid pr entirely volatile (when heated on porcelain), when it consists of sulphide of *arsenic* only; or it is a *ductile* bead (*tin*), or a *brittle* one (*antimony*), and at the same time an alliaceous odor (*arsenic*). acid, with the addition of a little chlorate of potassa, and heat the solution with metallic zinc; w acid produces a *brown* precipitate in the decanted solution, the presence of *tin* is proved. Th arsenic in Marsh's apparatus. Or the metallic sulphide has a *dark* color, owing to the presenc certainty by the reactions mentioned in the preliminary investigation, or in a detailed work on a

B. *Portion Insoluble in Sulphide of Ammonium.*[1]—The precipitate, after being well washed, when it is either *entirely* dissolved, or leaves a *residue*. The nitric solution may contain the ox expected in the investigation of ores of platinum.

The residue may consist of:

Sulphur.	*Sulphide of Mercury.*	*Sulphate of Lead.*
It consists of yellow or gray lumps, which often inclose a metallic sulphide.	Black, easily soluble in aqua regia, forming chloride of mercury; gives a metallic deposit with soda in an open tube.	White powder, not volatile, soluble in tartrate of ammonia; gives a bead of lead with soda on charcoal.

If *sulphide of mercury* is found, the original solution is tested whether the metal is present as *protoxide* or *suboxide*, or a *mixture of the two*. Treat it with *chlorohydric acid*.

Precipitate:	*Filtrate:*
Sub-chloride of Mercury. Assumes a black color with ammonia or potassa.	Proto-chloride of Mercury. Chloride of tin precipitates metallic mercury, which is easily recognized by rubbing it on clean copper.

Precipitate:

Sulphate of lead; s luble in basic tartra of ammonia, in whic solution chromate potassa produces a ye low precipitate.

produces a *reddish-br* less, and produces a copper, by slightly ac precipitates carbonat through the solution, sulphides is brown, a

[1] If the original solution has been acidulated with chlorohydric acid, before precipitating by sul present, although proto-sulphide of mercury, produced from the protoxide which is not precipitated by determine whether the mercury is present as suboxide or protoxide, the original solution is *always* em

ATIVE ANALYSIS OF BASES.

AN ACIDULATED SOLUTION, AT A MODERATE TEMPERATURE.

in presence of copper, with sulphide of potassium. It dissolves, according to Table IV., either ipitate is subjected to the same treatment; which is ascertained by adding an excess of chlorohy- tallic oxide, while a milky, white deposit indicates sulphur only.

ntes from the solution in sulphide of ammonium may either be *yellow*, soluble in *ammonia*, and *e* or *orange*, *not at all* or only *partially volatile*, and yields with cyanide of potassium (or charcoal) der to test for tin, arsenic, and antimony, simultaneously, dissolve the precipitate in chlorohydric e precipitated black metallic powder, and heat it with chlorohydric acid; and if now sulph-hydric of the metallic powder which remained insoluble in chlorohydric acid is tested for antimony and ither *gold*, *platinum*, *iridium*, *molybdenum*, or *tellurium*, which may be ascertained with sufficient is. To ascertain in what state the metal was present, the original substance is always employed.

solved in concentrated *nitric acid* (which must be free from chlorine) with the assistance of heat; of lead, silver, bismuth, copper, cadmium, and palladium. *Rhodium* and *osmium* are only to be

Add dilute sulphuric acid to the nitric solution:

Add chlorohydric acid to the filtrate:

Precipitate:	*Supersaturate the filtrate with ammonia:*	
	Precipitate:	*The filtrate may contain:*
Chloride of silver; soluble in ammonia, from which solution nitric acid reprecipitates it.	Oxide of bismuth. Its solution in little chlorohydric acid produces cloudiness with water.	Oxide of copper, oxide of cadmium [protoxide of palladium].

In presence of oxide of copper, the ammoniacal solution is *blue*, and, after being acidulated with chlorohydric acid, ecipitate with ferrocyanide of potassium; and in presence of cadmium *alone* the liquid is color- precipitate with sulph-hydric acid. Oxide of cadmium is recognized in presence of oxide of ing the solution with chlorohydric acid, and supersaturating with carbonate of ammonia, which admium. Or an excess of cyanide of potassium is added, and sulph-hydric acid is passed precipitates only the cadmium. In presence of palladium, the nitric solution of the metallic oduces a black precipitate with iodide of potassium.

dric acid, *sulphide of silver* and *sulphide of mercury*, produced from the *suboxide* (subsulphide), cannot be ydric acid may be present. If the solution was acidulated with *nitric acid*, *all these* may be present. To

TABLE VI.—SYSTEMATIC QUA

C. TREATMENT OF THE PRECI

When *nickel* is present, the filtrate is brown. The precipitate, *after being well washed*, is nickel) remains, it is tested by the blowpipe for cobalt. The precipitate is now completely di potassa);[1] an excess of *caustic potassa* is added, and the precipitate which remains is separated be treated with potassa; and when iron is present, the original solution is used to determine wh

The *filtrate* may contain:[2]

Oxide of chrome, oxide of zinc, alumina [glucina].
Boil for some time the (green) alkaline solution:

Precipitate:	The *filtrate* may contain
Oxide of chrome (and glucina). Test by blowpipe	Oxide of zinc, Alumina [Glucina].

Separate the filtrate into two portions and add:

Sulph-hydric acid to one part:	to the other part a sufficient quantity of chlorohydric acid, and then carbonate of ammonia.
Precipitate: Sulphide of zinc.	*Precipitate:* Alumina [glucina]. Test by blowpipe. (Glucina is soluble in carbonate of ammonia.)

Oxides of cobalt, nickel,

Dissolve the preci

The *liquid* (or
Oxides of cobalt,
Pass sulph-hydric acid
acidulated with acetic a

Precipitate:
Sulphide of cobalt,
" nickel,
(" zinc).

Put the precipitate be
fore the blowpipe for *co*
balt; dissolve in nitro-mu
riatic acid, add potassa t
nearly neutralize, add cy
anide of potassium, an
boil: a precipitate or addi
tion of chlorohydric o
sulphuric acid shows th
presence of *nickel.*

[2] In order to detect small quantities of *alumina*, in the presence of peroxide of iron, the precipitate by sulphide of ammonium is boiled with potassa, and the filtrate, after being treated with an excess of chlorohydric acid, is neutralized with carbonate of ammonia. *Oxide of iron* and *oxide of chrome* follow each other in being precipitated, according to their relative quantity. From a solution which contains magnesia besides alumina (or oxide of chrome), part of the *magnesia* always precipitates by ammonia, together with the other oxides, as a gelatinous compound, insoluble in potassa. They can be separated by repeated solution in chlorohydric acid and precipitation by ammonia, in presence of a large quantity of chloride of ammonium. The separation of *oxide of chrome* from alumina, magnesia, and oxide of iron is effected more perfectly by fusion with a mixture of carbonated alkali and saltpetre. To separate phosphoric acid from alumina, dissolve the combination in caustic soda, dilute the solution, and precipitate the phosphoric acid by chloride of barium or hydrate of baryta, adding gradually more caustic soda and some carbonate of soda, and heating to near the boiling point. The filtrate will contain the alumina.

[3] The separation of oxide
of potassa, is not perfect, f
sent, a small quantity of t
ammoniacal solution, wher
Oxide of iron may be separa
present only in very small
manganese, nickel, and co
slightly acidulating it, with a
all the iron precipitates, pr

[1] Before adding caustic potassa, boil the solution, to test for *titanic acid*, which then precipitates.

ATIVE ANALYSIS OF BASES.

TE BY SULPHIDE OF AMMONIUM.

lved on the filter in warm, dilute, chlorohydric acid. If a *black* residue (of sulphide of cobalt or d in cold concentrated chlorohydric acid, with the addition of a little nitric acid (or chlorate of tration. If the substance to be tested is known to contain but one base, the original solution may it is present as protoxide or as peroxide.

The precipitate may contain

anese, iron, and uranium; phosphates of baryta, strontia, lime, and magnesia; oxalate of lime ate of lime), [and all the rare earths which are insoluble in potassa.]
after washing, in little chlorohydric acid; and add chloride of ammonium and ammonia.

) may contain:[3]
manganese (zinc).
gh the solution, *slightly* nd apply *moderate* heat.

The *precipitate* may contain:
Oxide of iron, oxide of uranium, phosphates of the alkaline earths, oxalate of lime, fluate of lime [and all the rare earths].
Digest the precipitate with a concentrated solution of carbonate of ammonia.[4]

Filtrate:
Protoxide of manganese.
Evaporate to dryness, and fuse the residue with carbonate of soda and nitrate of potassa on platinum foil; when a bluish-green color proves the presence of manganese.

The solution may contain:
Oxide of uranium.
Test with ferrocyanide of potassium in chlorohydric solution.
Oxide of cerium,
" lanthanum.
" didymium,
Yttria,
Thoria,
Zirconia.
They almost all form double salts with sulphate of potassa, which are soluble with great difficulty.

The residue may contain:
Oxide of iron, phosphates of baryta, strontia, lime, and magnesia, oxalate of lime, and fluate of lime.
Dissolve in little chlorohydric acid, and test:

a. For *oxide of iron* with ferrocyanide of potassium. b. For *phosphoric acid* with little chloride of iron and acetate of soda, or with molybdate of ammonia. c. For *baryta* and *strontia* with sulphate of lime. d. For *lime* with oxalate of potassa and acetate of soda; *oxalate of lime* (and phosphate of iron) is precipitated by acetate of soda alone, and the precipitate is changed into carbonate of lime by calcination. e. Test the original substance or the dry residue, for fluorine, with sulphuric acid. A mixture of the phosphates of the alkaline earths with that of iron, as it occurs in ashes, is freed from phosphoric acid by boiling with acetate of soda and perchloride of iron; after which the filtrate is examined as usual, according to Tables VII. and VIII.

rom oxide of iron, by means h reason, when zinc is pre- tal always passes into the found as sulphide of zinc. e perfectly, especially when y, from the oxides of zinc, boiling the solution, after n of acetate of soda; when t is present as peroxide.

[4] The operation of digesting with carbonate of ammonia is only performed when there is reason to expect the presence of one of the rare oxides.

, and add potassa to the filtrate.]

TABLES VII. AND VIII.—SYSTEMA

D. TREATMENT OF THE PRECIPITATE BY CARBONATE OF AMM

Carbonate of baryta, stronti

The precipitate, after being washed, is dissolved on the filter in

PORTION I.	PORTION II.	
Add *sulphate of lime.*	Precipitate with an excess of dilute sulphuric acid,[1] superneutralize the filtrate with ammonia, and add oxalate of potassa.	I
Immediate precipitation:	Precipitate, insoluble in acetic acid:	du
Baryta.	Lime.	
Precipitation after some time:	[1] The precipitation by sulphuric acid is unnecessary if baryta or strontia are present.	
Strontia.		
The liquid remains clear:		
Lime.		

E. TREATMENT OF THE LIQUID WHICH IS PRECIPITATED NEITHER BY SULPH

It may contain: *magnesia, potassa, sod*

Part of the liquid is first evaporated on platinum foil; and, if no

TEST FOR AMMONIA.	TEST OF MAGNESIA.
Add *an excess of caustic lime* to the *original substance*, or *its* solution (*not* to the liquid VIII.), and apply moderate heat.	Add *phosphate of soda* and free ammonia to *a part* of the liquid VIII., or to the original solution, provided the latter contains no metallic oxides and no alkaline earths.
The presence of	The presence of
ammonia	*magnesia*
is proved by its odor, as well as by the white fumes which form when a glass rod, moistened with chlorohydric acid, is brought into its vicinity.	is proved by a crystalline precipitate, which forms but slowly when only a trace of magnesia is present.

QUALITATIVE ANALYSIS OF BASES.

IN PRESENCE OF CHLORIDE OF AMMONIUM AND FREE AMMONIA.

ime; or a mixture of the three.

chlorohydric acid, and the solution is divided into three portions.

PORTION III.	NOTE.
ate to dryness, digest the resi- alcohol, and ignite the *filtrate.* Crimson flame: Strontia.	In a mixture of baryta, strontia, and lime, the presence of *baryta* may be proved, *with certainty,* by a solution of sulphate of strontia, which gives in its presence a white precipitate, which does not appear immediately when only a trace of baryta is present. Baryta is *separated* from strontia by means of silicofluohydric acid, with the addition of some alcohol, in which silicofluate of baryta is quite insoluble.

RIC ACID, NOR BY SULPHIDE OF AMMONIUM, NOR BY CARBONATE OF AMMONIA.

ia, ammonia, or a mixture of these bases.

remains after heating to redness, ammonia only need be looked for.

TEST FOR POTASSA, SODA, AND LITHIA.

In the absence of magnesia. Evaporate that part of the liquid VIII. to which *no* phosphate of has been added, to dryness; apply stronger heat until all ammoniacal salt is volatilized, and test sidue before the blowpipe on platinum wire, or by adding alcohol and igniting it. A *violet flame* tes *potassa* only, a *crimson flame, lithia* only, and a *yellow flame* shows the presence of soda, or *ture of soda* with either potassa or lithia. In the latter case, test the residue: for *potassa,* with ic acid or chloride of platinum and alcohol, in a concentrated solution; and for *lithia,* by boiling quid down with carbonate and phosphate of soda, when a salt, difficult of solution, is formed; or nixture of ether and absolute alcohol, in which *chloride of lithium* is soluble.

In presence of magnesia. Evaporate to dryness, and heat to redness until all ammoniacal salt is off. Dissolve the residue in hot water, add hydrate of baryta until alkaline reaction ensues, and filter. After removing the excess of baryta by means of ammonia and carbonate of ammonia dilute sulphuric acid), evaporate the filtrate to dryness, and heat the residue, if there remains according to A.

TABLE IX.—PRELIMINA

BEHAVIOR OF THE MOST IMPORTANT ACIDS, OR HALOIDS, ON H

To a small quantity of the dry combination, placed in a test-tube, add three or four times it when all acids which are volatile, or decomposable by sulphuric acid at a high temperature, giv determined.

NON-VOLATILE ACIDS.	ACIDS WHICH ARE VOLA	
No gas or vapor is developed. The substance does not blacken by heat.	*Colored gas is developed. The substance does not blacken by heat.*	*The substan*
Silicic acid; test before the blowpipe with microsmic salt.	*Iodohydric acid;* the violet fumes color starch blue.	*Carbonic acid* cipitates lim
Boracic acid; colors the flame of alcohol green, after addition of sulphuric acid.	*Bromohydric acid;* the brown fumes color starch yellow.	*Cyanic acid;* e and precipit
Phosphoric acid; is precipitated in a neutral solution by sulphate of magnesia, chloride of ammonium and ammonia; and in an acid solution by perchloride of iron and acetate of soda.	*Bromic acid;* same as bromohydric; the combination deflagrates on charcoal.	*Sulphurous ac* colors a so potassa gre
Arsenic acid; same as phosphoric acid; and the compound gives arsenical odor when heated with soda on charcoal.	*Chloric acid;* the greenish-yellow fumes explode easily; the substance deflagrates on charcoal.	*Sulph-hydric* odor; color
Sulphuric acid; the compound gives hepar with soda on charcoal.	*Hypochlorous acid;* the greenish-yellow fumes of chlorine (the same as those developed by chloric acid) discolor solution of indigo.	*Chlorohydric* gives a che solution of
Selenic acid; same as sulphuric. The salt of baryta is decomposable by boiling with concentrated chlorohydric acid.	*Nitrous acid;* red fumes; the combination precipitates salts of lead.	*Fluohydric a* etches glas cloudiness
Tungstic acid; test by blowpipe. Turns blue with zinc and chlorohydric acid.	*Nitric acid;* almost colorless acid fumes, which are red in presence of chlorine, and assume a dark-red color on addition of proto-chloride of iron.	*Silicofluohydr* hydric; the a precipitat
Molybdic acid; test by blowpipe. Turns blue, and changes to brown, with zinc and chlorohydric acid.		*Nitric acid;* which turn of protosul per filings.
Titanic acid; test by blowpipe. Turns violet with zinc and chlorohydric acid.		
Iodic acid; gives off violet fumes of iodine on addition of protosulphate of iron. The combination deflagrates on charcoal.		

NOTE.—If, by the above methods, a hydracid is found, the dry substance contains the correspond salts, other reactions often take place; as, *e. g.*, a mixture of a nitrate with a metallic chloride wou give brownish-red fumes of chlorochromic acid, etc. The chlorides of *mercury* are scarcely decomp acid with concentrated sulphuric acid.

EXAMINATION OF ACIDS.

NG THEIR COMBINATIONS WITH CONCENTRATED SULPHURIC ACID.

me of concentrated sulphuric acid, and apply heat, without allowing the sulphuric acid to boil; ases or fumes, from the properties of which the nature of the acid or haloid may in most cases be

OR WHICH IN DECOMPOSING DEVELOP VOLATILE PRODUCTS.

The vapor or gas which is developed is colorless.

not blacken by

hout odor; pre-
er.

the eyes to tears,
ime-water.

own by its odor;
of chromate of

known by its
paper brown.

gives fumes; and
recipitate with a

gives off fumes;
id produces no
olution of silver.

d; same as fluo-
gives with water
ilica.

colorless fumes,
red on addition
of iron or of cop-

The combination is decomposed at a high temperature.

Without separation of carbon.

Oxalic acid; develops carbonic acid and oxide of carbon; the salt of lime is insoluble in acetic acid.

Formic acid; develops only combustible carbonic oxide gas.

Cyanohydric acid (prussic acid); same as formic acid, but develops prussic acid with dilute chlorohydric acid.

Ferrocyanohydric acid; same as prussic; its soluble compounds are precipitated blue by *persalts of iron.*

Ferridcyanohydric acid; same as prussic; its soluble compounds are precipitated blue by *protosalts of iron.*

Chromic acid; develops oxygen, and colors the flame brown or green. Gives a green bead with mic. salt.

Dithionic acid;
Trithionic acid;
Tetrathionic acid;
Pentathionic acid;
} develop sulphurous acid, while sulphur is set free and separates.

With separation of carbon.

A. *Acids non-volatile per se.*

All combinations of these acids are decomposed with concentrated sulphuric acid, and blacken while they develop CO_2, CO, and SO_2.

Tartaric acid; the acid salt of potassa is soluble with difficulty; the salt of lime is soluble in caustic potassa.

Racemic acid; the salt of lime is insoluble in chloride of ammonium.

Citric acid; gives a precipitate with an excess of lime-water only on boiling.

Malic acid; precipitates lime-water neither warm nor cold.

Tannic acid; gives a white, tough precipitate with glue; a bluish-black one with persalts of iron.

Gallic acid; does not precipitate glue; salts of proto-peroxide of iron give a black precipitate.

Uric acid; shows a red color with ammonia after being evaporated with nitric acid.

B. *Acids volatile per se.*

The substance blackens not at all, or very little, with sulphuric acid.

Acetic acid; gives with oxide of lead an alkaline salt; develops acetic ether with sulphuric acid and alcohol; [its salts develop kakodyl, known by its odor, when heated with arsenious acid].

Benzoic acid;
Succinic acid;
} Perchloride of iron gives a light-brown precipitate with their neutral salts.

loid bound to the metal. In the case of a mixture of different elop chlorine and red fumes; a chloride and a nitrate would by sulphuric acid. *Metallic sulphides* often develop sulphurous

TABLE X.—BEHAVIOR OF THE M

A. *Testing for Acids in Soluble Compounds.*—The aqueous solution is either *neutral, acid,* or as possible, or in presence of free ammonia, it often becomes necessary to remove the metallic as the phosphoric or oxalic acid which was combined with the alkaline earths. The quality of ing for them superfluous; in general, an acid cannot be present in a neutral or acid solution w is tested for by a solution of baryta, can be present in a solution which already contains baryt in alkaline solutions see below, Table X.). In any solution, such acids need of course not be agent might effect a precipitation by its *acid* (or haloid), the *nitrate* of the same base is chosen combinations of silver, lead, or suboxide of mercury. (For continuation, see Table XI.)

CHLOROHYDRIC OR NITRIC ACID *PRECIPITATES:*	CHLORIDE OF BARIUM *PRECIPITATES:*	
From their soluble compounds, which mostly show alkaline reaction.	From their solutions previously acidulated with chlorohydric or nitric acid.	Only fron The precipit
Silicic acid; gelatinous; appearing in dilute solutions only on evaporation of the acid liquid; precipitable, also, by carbonate of ammonia.	*Sulphuric acid;* white, pulverulent; quite insoluble in water or acids.	*Phosphoric a* acetic acid, when freshl
Boracic acid; crystalline, only from concentrated solutions. Colors the flame of alcohol green on addition of sulphuric acid.	In presence of too much concentrated free acid, a precipitate may ensue in the absence of sulphuric acid, as chloride of barium and nitrate of baryta are not very soluble; which may be ascertained by adding a large quantity of water: if the precipitate remains undissolved, it is sulphate of baryta.	*Arsenic acid;* soluble in The acid sol sulfhydric heat.
Antimonic acid; white, soluble in tartaric acid.	*Selenic acid;* same as sulphuric. The precipitate develops chlorine on being boiled with concentrated chlorohydric acid.	*Boracic acid;* chloride of only from c
Tungstic acid; white, gives a blue liquid with zinc and chlorohydric acid.	*Silico-fluohydric acid;* gelatinous, scarcely visible: the precipitate is decomposed by concentrated acids.	*Carbonic acid* with efferve
Molybdic acid; white, soluble in an excess. Gives with zinc and chlorohydric acid a blue liquid, changing to green and black.		*Sulphurous a* concentrate sulfhydric chlorohydri
Also: several *oxides* and *sulphides* which are soluble in potassa, and *cyanides,* or *chlorides* soluble in cyanide of potassium. On saturating the alkaline liquid with sulfhydric acid, and acidulating with chlorohydric or nitric acid, all *metallic acids,* which form sulphides insoluble in acids, are precipitated.		*Tartaric acid;* ride of amm the alkaline tate become
Of organic acids, *benzoic, uric,* and *tartaric acids* (the latter as bitartrate of potassa) may be precipitated by strong acid from an alkaline solution.		*Racemic acid* precipitate of ammoniu
		Citric acid; on boiling t excess of a

ine; which is to be ascertained by test-paper. If the acid is to be tested for in as neutral a solution or the earths (according to Table IV.); by which means the *acids of the metals* are found, as well se which has been found often excludes the presence of one or more acids, thus rendering the test- contains the same oxide by which the acid is to be precipitated; as *e. g.*, no sulphuric acid, which d in a combination of silver, which is soluble in acids, no chlorine can be present (for exceptions l for which have *been used* in it to effect solution or neutralization: and in all cases where the re- nitrate of baryta is used in preference to chloride of barium, in testing, in a liquid which contains

	CHLORIDE OF CALCIUM *PRECIPITATES:*	SULPHATE OF MAGNESIA (OR CHLORIDE OF MAGNESIUM) *PRECIPITATES:*
ral solutions. soluble in acetic il.	From a neutral or acetic solution. The precipitate is insoluble in acetic acid.	In presence of ammonia and chloride of ammonium.
white, soluble in out effervescence, ipitated. as phosphoric; te of ammonium. is precipitated by when assisted by	*Oxalic acid;* white; the precipitate develops carbonic acid with acids after calcination. *Fluo-hydric acid;* gelatinous; the precipitate develops, with sulphuric acid, fluo-hydric acid, which etches glass. *Sulphuric acid;* white, only from concentrated solutions; perfectly on addition of alcohol.	*Phosphoric acid;* white, crystalline; slowly from dilute solutions; soluble in all acids. *Arsenic acid;* same as phosphoric. The *acid* solution of the precipitate is precipitated by sulhfydric acid with assistance of heat. *Turtaric acid;* white, only from concentrated solutions; the precipitate blackens on being heated to redness.
, easily soluble in nium; precipitates rated solutions. e, soluble in acids . white, only from ations; develops with zinc and	*Separation of oxalic, tartaric, citric, and malic acids.*	
	Add lime-water until alkaline reaction ensues.	
e, soluble in chlo- a and in potassa; on of the precipi- ly by boiling. e as tartaric; the oluble in chloride	The *liquid* contains, in combination with lime: *Citric acid* and *malic acid.*	The *precipitate* contains, in combination with lime: *Oxalic acid* and *tartaric acid.*
	Boil.	Treat with cold caustic potassa.
	Precipitate: *Citrate of lime.* Soluble in a solution of chloride of copper.	*Filtrate:* *Malate of lime.* Precipitated by alcohol after evaporation.
precipitates only id after adding an a or caustic lime.		*Residue:* *Oxalate of lime.* Insoluble in acetic acid and in chloride of copper; soluble in chlorohydric acid.
		Filtrate: *Tartrate of lime.* Gives a gelatinous precipitate on boiling the potassic solution.

TABLE XI.—BEHAVIOR OF THE MOST IMPORTANT

B. *Testing for Acids in Compounds which are insoluble in Water and Acids.*—From the pre possible presence of any acids must be known. *Inorganic* compounds (which separate no carb bonated alkali, and the *aqueous* extract (neutralized with chlorohydric, nitric, or acetic acid) is t be decomposed by digesting them with sulphide of ammonium, as well as the sulphates of the e ing the acid. Sulphides yield *sulphuric acid* on being treated with nitric acid, aqua regia, or cl posed by boiling with carbonated alkali; and the salts formed by organic acids with protoxide o for it according to Tables X. and XI.

ACIDS TESTED BY PERCHLORIDE OF IRON:

Producing a precipitate.	Changing the color of the liquids.	From *neu*
A. *In presence of free chlorohydric acid:*	A. *In presence of free chlorohydric acid:*	*The precipi*
Ferro-cyanohydric acid; blue; potassa decomposes the precipitate into peroxide of iron and ferrocyanide of potassium.	*Ferrid-cyanohydric acid;* brownish. Persalts of iron give a blue precipitate.	*Phosphoric a* precipitated nesia with ammonium.
B. *In neutral solutions or such as contain only free acetic acid:*	*Sulpho-cyanohydric acid;* intensely blood-red, not disappearing by an excess of chlorohydric acid, changed to yellow by adding chloride of gold.	*Arsenic acid;* nal solution sulfhydric
(When free chlorohydric acid is present, neutralize with acetate of soda.)	B. *In neutral solutions only:*	*Arsenious aci* spects like
Phosphoric acid; yellowish-white, insoluble in acetic acid, soluble in chlorohydric acid and acetate of iron.	*Acetic acid;* reddish-brown; the original substance, on being heated with alcohol and sulphuric acid, smells of acetic ether.	*Chromic acid* tion, which lored green
Arsenic acid; same as phosphoric; the original substance gives alliaceous odor with soda.	*Formic acid;* reddish-brown. The original substance reduces oxide of silver or mercury with development of carbonic acid.	*Oxalic acid;* acid.
Tannic acid; blackish-blue. The original solution is precipitated by glue.	*Sulphurous acid;* reddish-brown. The color disappears by boiling, without precipitation. The original substance gives off the odor of sulphurous acid by adding chlorohydric acid.	*Boracic acid;* acid; colo green, afte acid.
C. *In neutral solutions only:*	*Meconic acid;* blood-red, unchangeable by chloride of gold.	
Benzoic acid; light-brown. Chlorohydric acid gives a crystalline precipitate in the original solution.	*Gallic acid;* black. The original solution gives no precipitate with glue.	
Succinic acid; same as benzoic. The concentrated solution of its salt with ammonia (obtained by digesting the iron salt with ammonia) is precipitated by chloride of barium in presence of alcohol and free ammonia.		

[1] All these ammonia. *M phoric acid*, or white by nitra precipitated by of acetic acid.

DS TO REAGENTS, INCLUDING SOLUTION OF INDIGO.

ıry examination, according to Tables I., III., and IX., the general nature of the substance, and the ı being calcined) are fused, in the shape of a fine powder, with four times their weight of *pure* car- l according to Tables X. and XI. Insoluble compounds of the oxides of the heavy metals may also ıe earths, by boiling with a concentrated solution of carbonate of soda; the filtrate always contain- ydric acid and chlorate of potassa. Salts of *organic* acids, which are insoluble in water, are decom- also by ammonia; the filtrate, always containing the acid in combination with the alkali, is tested

ITRATE OF SILVER PRECIPITATES:

olutions only.

soluble in dilute ıcid:

ribasic); yellow; ıy sulphate of mag- ıia and chloride of

ıish-red; the origi- a precipitate with

llow; in other re- e acid.

the original solu- l or yellow, is co- lphurous acid.

insoluble in acetic

, soluble in acetic flame of alcohol ıtion of sulphuric

ates are soluble in and *bibasic phos-* lts, are precipitated ilver; and they are en after the addition

From neutral or *acid* solutions:

The precipitate is insoluble in dilute nitric acid:

Chlorohydric acid; white; soluble in ammonia and in hyposulphite of soda.

Bromohydric acid; same as chlorohydric. The original substance imparts a yellow color to ether, on addition of solution of chlorine.

Iodohydric acid; yellowish, insoluble in ammonia. The original substance, treated with nitric acid and starch, colors the starch deep blue.

Iodic acid; white, soluble in ammonia, from which sulphurous acid precipitates iodide of silver. The original substance, with acetic acid and starch, colors starch blue.

Cyanohydric acid; white, soluble in ammonia and in sulphite of soda. The original solution gives Prussian blue with protopersalts of iron, potassa, and chlorohydric acid.

Ferro-cyanohydric acid; white, insoluble in ammonia. The original solution gives Prussian blue with a persalt of iron alone.

Sulpho-cyanohydric acid; white, insoluble in ammonia; the original solution is colored blood-red with perchloride of iron.

Sulfhydric acid; black, insoluble in ammonia; salts of lead and copper also give a black precipitate.

ACIDS WHICH DISCOLOR INDIGO SOLUTION.

A. *Without addition of an acid.*

Free *chlorine* and *bromine; hypochlorous, chlorous,* and *hypochloric acid,* as well as the *hypochlorites;* and free concentrated *nitric acid.*

B. *On addition of an acid (chlorohydric or sulphuric) and application of heat:*

Chlorates; they leave chlorides after calcination.

Nitrates; the liquid assumes a darker color with proto-sulphate of iron and sulphuric acid.

Iodates; the dry original substance gives violet fumes of iodine with proto-sulphate of iron and sulphuric acid.

Bromates; they give, with sulphuric acid, brown fumes of bromine.

C. *With development of chlorine on boiling with concentrated chlorohydric acid:*

All the above combinations, and:

Chromates.

Selenates.

Tellurates.

The *higher oxides* and the *acids of manganese.*

TABLE XII.

EQUIVALENTS OF THE SIMPLE SUBSTANCES, H = 1.

Aluminum	Al	13.7	Mercury	Hg	100
Antimony	Sb	129	Molybdenum	Mo	46
Aridium*	Ar	—	Nickel	Ni	29.6
Arsenic	As	75	Niobium†	Nb	—
Barium	Ba	68.5	Nitrogen	N	14
Bismuth	Bi	213	Osmium	Os	99.6
Boron	B	10.9	Oxygen	O	8
Bromine	Br	80	Palladium	Pd	53.3
Cadmium	Cd	56	Pelopium†	Pe	—
Calcium	Ca	20	Phosphorus	P	32
Carbon	C	6	Platinum	Pt	98.7
Cerium	Ce	47	Potassium	K	39.2
Chlorine	Cl	35.5	Rhodium	R	52.2
Chromium	Cr	26.7 (?)	Ruthenium	Ru	52.2
Cobalt	Co	29.5	Selenium	Se	39.5
Columbium	Ta	184	Silicium	Si	21.3
Copper	Cu	31.7	Silver	Ag	108
Didymium	D	50	Sodium	Na	23
Donarium*	Do	—	Strontium	Sr	43.8
Erbium†	E	—	Sulphur	S	16
Fluorine	F	19	Tellurium	Te	64.2
Glucinum‡	Be (G)	4.7	Terbium†	Tb	—
Gold	Au	197	Thorium	Th	59.6
Hydrogen	H	1	Tin	Sn	58
Iodine	I	127.1	Titanium	Ti	25
Iridium	Ir	99	Tungsten	W	95
Iron	Fe	28	Uranium	U	60
Lanthanum	La	47	Vanadium	V	68.6
Lead	Pb	103.7	Yttrium†	Y	—
Lithium	Li	6.5	Zinc	Zn	32.6
Magnesium	Mg	12	Zirconium	Zr	22.4
Manganese	Mn	28			

* Newly discovered.

† Not accurately determined.

‡ According to the formula of glucina BeO, (GO); but for the formula Be_2O_3 (G_2O_3) the equivalent of glucinum = 7.

NOTES ON TESTING.

The test tubes used should be seven inches in length and three-quarters of an inch in diameter, so that they can be fully closed with the thumb. When so closed, and held between the first and second fingers, the liquid can be violently agitated, which often promotes the formation of a precipitate. If the solution be acid or hot, the tube may be held between the thumb and first two fingers, and agitated by the others. When it is necessary to boil or apply heat, it is always well to turn the mouth of the tube away from you to avoid accidents to yourself or fellow-workers. In examining a salt, one-half, about ten or twelve grains, should be dissolved in half a test tube full of distilled water by the aid of heat; and in the case of bismuth and a few other metals, by the addition of a few drops of nitric or hydrochloric acid—preferably nitric. For rendering insoluble substances soluble, see under the proper head. Beginners should commence with bodies that dissolve easily.

The solution so obtained is called the original solution, and should always be placed in one particular hole of the test tube stand, say the upper one on the left.

A portion of this, say half an inch, being poured out into a second tube, and diluted with about an equal bulk of water, the tests may be applied as in Table I. In adding hydrochloric acid, only a few drops should be used at first, and if a precipitate is formed, a little more added to see whether it dissolves or not. In using hydrosulphuric acid, a large quantity should be employed,

say an equal bulk ; and it must be remembered that this re-agent spoils very rapidly, and must often be prepared afresh. Some other re-agents, such as ammonium chloride, and calcium sulphate, must also be used in rather large quantity ; the same with sodium phosphate. In using Table VII., the original solution should not be diluted.

In trying the solubility of the sulphides in ammonium sulphide or acid, it is better to allow the precipitate to settle, and to pour off as much of the liquid as possible; and the same applies to many other precipitates. In using ammonium sulphide, the solution will almost always become more or less yellow, and any light coloured precipitate the same, especially if the sulphide is not fresh. Very old sulphide is often quite colourless, and then, of course, useless.

Precipitates when formed rapidly from concentrated solutions are generally amorphous, without any visible crystalline structure, even when viewed under the magnifier; when formed slowly, and especially from dilute solutions, they are often highly granular and crystalline, sometimes forming on the sides of the tube. Much information may be derived by an examination of these crystals, either by the pocket lens or by a more powerful microscope.

The greatest care should be taken that the test tubes are perfectly clean. A piece of sponge, fastened on to a rod of wood eight or nine inches long, forms a convenient cleaner; the tubes being afterwards well rinsed with water. In most cases the latter only is required.

For ordinary working, the only requirements, in addition to tubes and stand, are—spirit lamp or gas burner, blow-pipe, charcoal, platinum foil and wire, platinum crucible desirable, but a

thin porcelain one will answer for many purposes; a few capsules or small dishes, funnels, filtering paper, glass rods and tubes, a pocket lens, and a few precipitating glasses, for larger quantities than could be contained in a test tube.

In using Table I., if no precipitate has been formed by hydrochloric acid, add hydrosulphuric acid to same solution, in small quantity at first (test for mercuric salts), and at last an equal bulk; if this produces nothing, or only a milkiness, add ammonium chloride in considerable quantity, then ammonia, until the liquid smells strongly after shaking; and then, whether any change has taken place or not, a small quantity of ammonium sulphide. If no change is hereby produced, add sodium carbonate to the same solution, or perhaps preferably to a fresh portion of the original.

It may of course happen that in the examination of an unknown substance no base is found, the body being an acid, and *vice versa*. Having determined the nature of the base or acid by the tables, refer back to special tests under the respective heads, and go through all the reactions with small portions of the original solution, omitting in most cases those by which the groups have been determined.

SYMBOLS AND ATOMIC WEIGHTS OF THE COMMONER ELEMENTS.

Oxygen	O	16	Aluminum	Al	27.4
Sulphur	S	32	Manganese	Mn	55
Chlorine	Cl	35.5	Iron	Fe	56
Bromine	Br	80	Cobalt	Co	59
Iodine	I	127	Nickel	Ni	59
Fluorine	F	19	Chromium	Cr	52.4
Nitrogen	N	14	Zinc	Zn	65
Phosphorus	P	31	Cadmium	Cd	112
Carbon	C	12	Copper	Cu	63.4
Boron	B	11	Lead	Pb	207
Silicon	Si	28	Tin	Sn	118
Hydrogen	H	1	Bismuth	Bi	210
Potassium	K	39	Antimony	Sb	122
Sodium	Na	23	Arsenic	As	75
Lithium	L	7	Silver	Ag	108
Barium	Ba	137	Mercury	Hg	200
Strontium	Sr	87.5	Gold	Au	197
Calcium	Ca	40	Platinum	Pt	197.4
Magnesium	Mg	24			

TABLE OF RE-AGENTS.

The formulas of these substances are given without reference to water of crystallization, as they are generally used, except in preliminary or blow-pipe tests, in form of solution. Where not mentioned, this will always be understood.

Sulphuric Acid	Hydrogen Sulphate .... H^2SO^4	SO^2 H^2	O^2
Nitric Acid	Hydrogen Nitrate .... HNO^3	NO^2 H	O
Hydrochloric Acid	Hydrogen Chloride ..... HCl	H Cl	
Hydrosulphuric Acid.....	Hydrogen Sulphide ..... H^2S	H H	S
Water	Hydrogen Oxide ..... H^2O	H H	O
*Oxalic Acid	Hydrogen Oxalate.... $H^2C^2O^4$	C^2O^2 H^2	O^2
Acetic Acid	Hydrogen Acetate .... $C^2H^4O^2$	C^2H^3O H	O
Tartaric Acid	Hydrogen Tartrate .... $C^4H^6O^6$	$C^4H^4O^4$ H^2	O^2
Ammonia	Ammonium Hydrate, NH^3H^2O	NH^4 H	O
Potassa	Potassium Hydrate .... HKO	K H	O
Soda	Sodium Hydrate ..... $HNaO$	Na H	O
Slaked Lime.....	Calcium Hydrate .... H^2CaO^2	Ca H^2	O^2
Sodium Carbonate	..... Na^2CO^3	CO Na^2	O^2
†Ammonium Carbonate....	..... Am^2CO^3	CO Am^2	O^2
Barium Chloride	..... $BaCl^2$	Ba Cl^2	
Calcium Chloride	..... $CaCl^2$	Ca Cl^2	
Magnesium Chloride, or	..... $MgCl^2$	Mg Cl^2	
Sulphate	..... $MgSO^4$	SO^2 Mg	O^2
Ammonium Chloride	..... $AmCl$	Am Cl	
Ferric Chloride	..... Fe^2Cl^6	Fe^2 Cl^6	

* Oxalic, Tartaric, Acetic and other Organic Acids, are often represented thus: $\overline{Ox}$, $\overline{T}$, $\overline{Ac}$, $\overline{Cl}$, $\overline{Tn}$, $\overline{Gl}$, &c.

† The commercial salt is generally a sesquicarbonate, or contains some bicarbonate; hence ammonia is added.

Platinic Chloride	$PtCl^4$	$Pt\ Cl^4$	
Stannous Chloride	$SnCl^2$	$Sn\ Cl^2$	
Copper Sulphate	$CuSO^4$	$SO^2\ Cu$	O^2
Potassium Ferrocyanide	K^4Cfy	$K^4\ Cfy$	
Potassium Ferricyanide	K^3Cfy	$K^3\ Cfy$	
Potassium Sulphocyanide	$KCyS$	$K\ Cy$	S
Potassium Chromate	K^2CrO^4	$CrO^2\ K^2$	O^2
Sodium Phosphate	Na^2HPO^4	$PO\ Na^2H$	O^3
Sodium Acetate	$NaC^2H^3O^2$	$C^2H^3O\ Na$	O
Sodium Nitroprusside	Na^2FeCy^5NO (?)	$Fe\ Cy^5X\ Na$	?
Ammonium Oxalate	$Am^2C^2O^4$	$C^2O^2\ Am^2$	O^2
Ammonium Sulphide	Am^2S	$Am^2\ S$	
Calcium Sulphate	$CaSO^4$	$SO^2\ Ca$	O^2
Silver Nitrate	$AgNO^3$	$NO^2\ Ag$	O
Ammonium Molybdate	Am^2MoO^4	$MoO^2\ Am^2$	O^2
Lead Acetate	$Pb2C^2H^3O^2$	$2C^2H^3O\ Pb$	O^2
Potassium Iodide	KI	$I\ K$	
Sulphindigotic Acid	$\overline{Ind}$		
Borax	$Na^2B^2O^4$	In blow-pipe tests.	
Microcosmic Salt	$NaHAmPO^4$		

ABBREVIATIONS USED IN FOLLOWING PAGES.

Precipitate	ppte.	Insoluble	insol.
Precipitant	pptt.	Volatile	vol.
Precipitated	pptd.	Sublimate	sub.
Precipitation	pptn.	Addition	adtn.
Solution	soln.	Original	orig.
Soluble	sol.		

TABLE I.—GROUP TESTS.

I. Adtn. of HCl to orig. soln. causes white ppte. insol. in excess of HCl.	II. Adtn. of H^2S to same soln. causes ppte., the colour of which is, if H^2S be added in excess,	III. Adtn. of Am^2S to same soln. after adding excess of AmCl and NH^3 produces ppte., colour of which is	IV. Adtn. of Na^2CO^3 to orig. soln. causes a white ppte. even in cold	V. No ppte. in orig. soln. by either of preceding re-agents.
Lead Silver Mercury in salts of lower oxide. Antimony in organic salts may give a ppte. sol. in excess. The same with Tungstates and, to some extent, with Molybdates.* Some chlorides, such as $BaCl^2$, NaCl, &c., are pptd. by HCl, ppte. sol. in excess of water.	*Black.* Platinum Gold Lead Copper Mercury *Brown-Black.* Bismuth *Brown.* Tin-stannous *Orange.* Antimony *Yellow.* Arsenic Tin-stannic Cadmium *White.* A ppte. or milkiness from S, in presence of salts of Fe^2O^3, CrO^3, Cl, &c.	*Black.* Iron Nickel Cobalt *Buff.* Manganese *Greenish Gray.* Chromium *White.* Zinc Aluminum These lighter colours may be much interfered with by presence of impurities. (See Table V.) If from acid solns., phosphates or oxalates may be present.	Barium Strontium Calcium Magnesium	Potassium Sodium Ammonium Lithium The last may give slight ppte. under IV. in concentrated solns. and heating.

* See Table II.

TABLE II.—GROUP I.*

Adtn. of NH^3.	Adtn. of NH^3.	Adtn. of NH^3.	The adtn. of a piece of Zn. to the acid soln.
Scarcely changes the ppte.	Dissolves the ppte.	Turns the ppte. gray or black.	Give dark blue colour after a short time.
Orig. soln. gives with H^2SO^4 a white ppte.	Orig. soln. gives a gray ppte. with $FeSO^4$.	Orig. soln. gives with H^2SO^4 a white ppte.	The acid soln., heated with a drop of sodium phosphate, gives a yellow ppte.
The ppte. by HCl is sol. in much boiling water.	White ppte. turns gray or black on exposure to sunlight.	On polished copper or gold a gray stain removed on heating.	Molybdic acid.
Orig. soln. gives yellow ppte. with K^2CrO^4.	Orig. soln. gives with K^2CrO^4 a scarlet ppte.	The white ppte., when boiled with HCl, turns gray.	Produces no yellow ppte.
Lead.	Silver.	Mercurous salts.	Tungstic or Metatungstic acid. See page 19.
			For antimony, see Table III.

* The ppte. formed on addition of HCl should be allowed to settle, the liquid poured off, and fresh portions of water added, the operation repeated. The settlement will generally be aided by violent agitation. This is supposing the ppte. is insol. in moderate excess of HCl.

TABLE III.—GROUP II (*a*).

Ppte. sol. in Am^2S, alone or on adtn. of S, Ppte. is

Black.	Black.	Yellow.	Yellow.	Orange.
Orig. soln. gives with KCl a yellow, more or less cryst. ppte. With KI a brown colour or dark ppte.	Orig. soln. gives with $FeSO^4$ a blue colour or brown ppte. With $\overline{Ox}$ on warming a blue colour, and ppte. of brown metal, sometimes on the glass with golden lustre.	Washed ppte. is sol. in NH^3. Orig. soln. gives with HKO no ppte. Dry salt heated in tube with dry Na^2CO^3 and KCy evolves garlic odour, and forms ring of brown colour or metallic lustre.	Washed ppte. is insol. in NH^3. Orig. soln. gives with HKO a white ppte. sol. in excess. Dry salt heated on charcoal with Na^2CO^3 and KCy gives metallic beads sol. in hot HCl, the soln. showing reactions of tin. The mass well fused may be picked out, ground with a little water in agate mortar, liquid poured off, when metallic scales will appear; same with copper, &c. If the orig. ppte. formed by H^2S was brown, stannous salt would be indicated. If yellow, then stannic salt.	Washed ppte. is sol. in HKO. Orig. soln. containing HCl gives with zinc a black ppte. and gas burning with white flame. Acid soln. gives on platinum foil when touched with zinc a black stain.
Platinum.	Gold.	Arsenic.	Tin.	Antimony.

TABLE IV.—GROUP II (*b*).

Ppte. insol. in fresh Am^2S, and even after adtn. of S, or use of old Am^2S, ppte. is

Black.	Black with excess of H^2S.	Brown-Black.	Brown-Black.	Yellow.
Orig. soln. gives with H^2SO^4 a white ppte. With HCl a white ppte. sol. in excess of boiling water. With KI a yellow ppte. sol. in large excess of boiling water. With K^2CrO^4 a * yellow ppte. sol. in large excess of HKO.	Orig. soln. gives bright yellow with HKO in excess. White turning to gray with $SnCl^2$, especially on heating. Stain on copper. Change of colour on adding H^2S, from white to orange and black is very characteristic, most so with $HgCl^2$.	Orig. soln. gives with HKO a blue ppte., turning black on heating with excess. Orig. soln. gives a fine blue colour with excess of NH^3. Orig. soln. forms red stain on iron, best in presence of acid.	Orig. salt does not dissolve in water, even on boiling, without aid of HCl or HNO^3. Gives ppte. with HKO, insol. in excess. Gives with K^2CrO^4 yellow ppte. insol. in excess.	Orig. soln. with NH^3 gives ppte. sol. in excess. Orig. soln. with HKO gives ppte. insol. in excess.
Lead.	Mercury.	Copper.	Bismuth.	Cadmium.

* In making this experiment, it is well to throw away the larger portion of the ppte., and act only on a small quantity. The same applies to all similar experiments.

TABLE V.—GROUP III.

DIVISION I.—Ppte. is Black.

The black sulphide should be allowed to settle, and washed several times with water, especially if nitric or chloric acid be present.

The addition of hydrochloric acid to the washed sulphide

Dissolves it.		Leaves it undissolved.	
Original solution gives with potassium hydrate or ammonia a dirty green precipitate, turning black and then brown.	Original solution gives with potassium hydrate or ammonia a brown precipitate. Organic acids interfere with these reactions.	Original solution gives with potassium hydrate a green precipitate, soluble in ammonia with a blue colour.	Original solution gives with potassium hydrate a blue precipitate, soluble in ammonia with a brown colour.
Iron in ferrous salts.	Iron in ferric salts.	Nickel.	Cobalt.

DIVISION II.—Ppte. is not Black.

The precipitates are all soluble in hydrochloric acid, and their colours are

Buff.	Greenish, or Gray.	White.	White.
Original solution gives with potassium hydrate a white precipitate, turning brown on exposure to the air.	Original solution gives with potassium hydrate a green or gray precipitate, soluble in excess to a fine green solution.	Original solution gives with ammonia a white precipitate, soluble in excess. The same with potassium hydrate.	Original solution gives with ammonia a white transparent precipitate, insoluble in excess. The same with potassium hydrate, but soluble in excess.
Manganese.	Chromium.	Zinc.	Aluminum.

This colour is often not pure buff, but grayish, if the salt be not pure. The same is the case with the precipitate formed from zinc and aluminum solutions. The tests with potassium hydrate or ammonia will decide the point.

From acid solutions white precipitates may be formed, consisting of earthy phosphates, oxalates, &c.

TABLE VI.—GROUP IV.

If the solution employed in the previous group tests is employed, that is, if salts of ammonia are present, it may be better to warm gently. With original solution this is not necessary.

The original solution, mixed with a large quantity of ammonium chloride and a moderate quantity of ammonium carbonate, gives

A white precipitate.			No precipitate.
Original solution gives, with calcium sulphate,			
A precipitate at once.	A precipitate after some time.	No precipitate.	The addition of sodium phosphate produces a precipitate, crystalline when from dilute solutions.
The salt colours the flame of alcohol green.	The salt colours the flame of alcohol crimson.	The salt colours the flame of alcohol orange red.	
Barium.	Strontium.	Calcium.	Magnesium.

TABLE VII.—GROUP V.

Original solution, rather concentrated, and acidulated with hydrochloric acid, gives, with platinum tetrachloride,

A yellow precipitate.		No precipitate.	
Dry salt heated with potassium hydrate, evolves no ammonia.	Dry salt heated with potassium hydrate, evolves ammonia.	Salts colour the flame of alcohol yellow.	Salts heated in blow-pipe flame produce a magnificent purple colour.
Dry salt colours the flame of alcohol violet.	Salts are volatile, and do not colour the flame of alcohol.		
Potassium.	Ammonium.	Sodium.	Lithium.

If no metal is found, the substance is probably an acid, and the base hydrogen.

NOTES ON TESTING FOR ACIDS.

If in solution, and the blackening effect of heat is to be tried, HKO may be added, and the whole evaporated to dryness. Salts should be tested as to their neutrality; if acid, a little ammonia may be added till alkaline and warmed. Many salts of the heavy metals cannot thus be neutralized, as the least trace of ammonia produces a precipitate, such salts being inherently acid.

It is always well to detect the base or metal first; this is specially the case with ammonium, some organic salts of which do not blacken when heated, and give no solid, but only a liquid sublimate. Moreover, many metals form insoluble salts with several acids; hence if the salt is easily soluble in water, these need not be looked for.

Ba, in soluble salt, precludes H^2SO^4, H^2CO^3, H^3PO^4, &c.

Pb precludes H^2SO^4, Cl (?) Br, I, H^2CO^3, H^3PO^4, &c.

Ag precludes Cl, Br, I, and so on.

TABLE VIII.—GROUPS

I. Salts, excepting some of NH^4, blackening more or less when heated in a close tube.	II. Salts not blackening when heated giving a ppte. with $BaCl^2$ in neutral solutions.	III. Salts not blackening giving no ppte. with $BaCl^2$, but with $AgNO^3$ in neutral or acid solutions.	IV. Salts deflagrating when heated on charcoal.
Strongly Tartaric Citric Tannic Gallic Uric Benzoic Acetic *Slightly* Oxalic Ferrocyanic Ferricyanic Sulphocyanic Many salts of ammonia volatilize or are decomposed without blackening.	Sulphurous Sulphuric Phosphoric Boracic Silicic Carbonic Hydrofluoric Oxalic (1st Group). Ferrocyanic (1st Group). Chromic Arsenic Arsenious	Hydrochloric Hydrobromic Hydriodic Hydrocyanic Hydrosulphuric Ferricyanic } 1st Sulphocyanic } Group.	Nitric Chloric Iodic Bromic Perchloric Lead oxide also deflagrates to some extent when heated on charcoal. Detected at once by formation of globules of metallic lead. $AmNO^3$ is decomposed with slight deflagration.

TABLE IX.—GROUP I.

Salts blackening in tube more or less.

I.	II.
Salts when heated evolving smell of burnt sugar, blackening rapidly when heated with H^2SO^4. Acid or salt with very large excess of lime water, gives white ppte., sol. in very large excess of HKO; give dark colour when boiled with $AgNO^3$. Acid gives ppte. with little HKO on shaking. Tartaric.*	Salts blacken very slightly, residue dissolves in acids with effervescence. Dry salt or acid heated with H^2SO^4 evolves a gas burning with blue flame. Ppte. with $CaCl^2$ insol. in acetic acid. With MnO^2 and H^2SO^4 violent effervescence. Oxalic.
Evolving acid smell when heated, blackening slowly with hot H^2SO^4. White ppte. with excess of lime water soluble in NH^3. No ppte. when shaken with little HKO. Citric.	Salts turn brown on heating; boiled with dilute H^2SO^4 give off smell of prussic acid, or with excess of strong H^2SO^4, a gas burning with blue flame. Ferrocyanic.
Blackens rapidly with H^2SO^4, gives blue-black colour with Fe^2Cl^6, precipitates gelatine. Tannic.	Salts turn brown on heating. Give dark blue colour with ferrous salts, brown colour with ferric. Ferricyanic.
Blackens rapidly with H^2SO^4, blue-black colour with Fe^2Cl^6, does not ppte. gelatine. Gallic.	Salts darken on heating. Dry mercuric salt swells up to voluminous ash. Red colour with Fe^2Cl^6, destroyed by $HgCl^2$, not by boiling. (See page 19.) Sulphocyanic.
Dry salt heated with H^2SO^4 evolves smell of vinegar, with alcohol added the sweet smell of acetic ether; with Fe^2Cl^6, red colour. Acetic.	
Heated with H^2SO^4, evolves pungent vapour. Solution gives buff ppte. with Fe^2Cl^6. Benzoic.	
Acid or salt, evaporated to dryness in capsule, with few drops of HNO^3 gives red colour, turning purple with HKO. Uric.	

* In ammoniacal solutions of tartrates, $CaCl^2$ produces a flocculent ppte., which soon becomes crystalline and insol. in acetic acid. It might thus be mistaken for oxalate, but this latter is dissolved by HCl, and reprecipitated by NH^3, while the tartrate is not reprecipitated. The strong blackening of the latter is also characteristic.

TABLE X.—GROUP II.

I.
Salts treated with moderately strong H^2SO^4, evolve a gas.

Without smell.

The gas decanted into a tube, and shaken with lime water gives a white ppte.

Carbonic

Smells of burning sulphur.

Gas acts on Iodic Starch paper, producing blue colour.

Salts boiled with Zn and HCl evolve H^2S, which blackens lead paper.

Sulphurous

Sol. salts evolve with acids H^2S, recognized by smell, and as above

Hydrosulphuric.

II.
Salts do not evolve a gas with H^2SO^4. Give a ppte. with $BaCl^2$.

Insol. in dilute HNO^3.

Salts heated on charcoal with Na^2CO^3 give a red mass, which when moistened forms a brown stain on silver.

The red mass evolves H^2S when treated with dilute H^2SO^4, and if dissolved in water gives fine purple colour with sodium nitroprusside.

Sulphuric

Sol. in dilute HNO^3.

Salts give a yellow ppte. with $AgNO^3$, and yellow with ammonium molybdate, especially on warming.

Phosphoric

Salts, treated with H^2SO^4 and burnt with alcohol, give green flame. Also free acid in blow-pipe flame. See Blow-pipe Tests.

Acid, when set free by HCl, turns turmeric paper dark brown red.

Boracic

Acid separated from its strong solutions as a jelly by HCl. On evaporating to dryness and treating residue with H^2O, becomes more visible and not gelatinous.

Silicic

Salts are red, yellow or brown. Yellow ppte. with lead acetate, scarlet with $AgNO^3$, turned green by boiling with HCl and alcohol or sulphurous acid.

Chromic

Brown red ppte. with $AgNO^3$, white ppte. with $MgSO^4$ and NH^3.

Arsenic.

(For Oxalic, Hydrofluoric and Ferricyanic, see Table and page 19.)

TABLE XI.—GROUP III.

Ppte. with $AgNO^3$ is insol. in dilut. HNO^3.

Black.	*Yellowish.*	*Brown-Yellow.*	*White.*
Sol. salts give a purple colour with sodium nitroprusside.	Insol. in NH^3.	Solutions give brown colour with Fe^2Cl^6.	Salts heated with H^2SO^4 evolve pungent fumes of HCl.
Black ppte. with salts of lead, many evolve H^2S with acids.	Dry salt heated with H^2SO^4 evolves violet fumes.	Ferricyanic.	On addition of MnO^2 evolve Cl, recognized by smell and bleaching power.
Dry salts heated with HNO^3, evolve red fumes, and the soln. contains H^2SO^4.	Solutions treated with Cl become yellow or brown, giving a blue colour with starch and a pink or dark colour when shaken with carbon disulphide, benzol or chloroform.	*Dull White.* Solutions give blue ppte. with Fe^2Cl^6.	Hydrochloric or chlorine.
Hydrosulphuric or sulphur.	Hydriodic or iodine.	Ferrocyanic, salts of which acid give a ppte. with $BaCl^2$, insol. in $\overline{Ac}$, hence resembling oxalates. For this reason H^4Cfy appears in two groups.	Salts heated with H^2SO^4 evolve HCy, recognized by odour, by being absorbed by Am^2S, and on evaporation giving a red colour with Fe^2Cl^6.
	Sol. in much hot NH^3.	Solutions give blood-red colour with Fe^2Cl^6.	Solutions mixed with both ferrous and ferric salts, pptd. by HKO and again dissolved in HCl, give blue colour or ppte.
	Dry salts heated with H^2SO^4 evolve white and yellow fumes.	Sulphocyanic.	Hydrocyanic or Cyanogen.
	Solutions treated with Cl and shaken with ether, yield to it a yellow colour, and the aqueous liquid becomes colourless.		
	Hydrobromic or bromine.		

TABLE XII.—GROUP IV.

No ppte. with $BaCl^2$ unless in very concentrated solns. ppte. sol. in much water. Dry salt heated with H^2SO^4 and metallic copper evolves red fumes. Salt or soln. heated with H^2SO^4 destroys the blue colour of $\overline{Ind}$.	No ppte. with $BaCl^2$. No ppte. with $AgNO^3$ till after heating the dry salt. Salts treated with H^2SO^4 turn reddish and evolve a gas Cl^2O^4 which is very explosive. On addn. of HCl or H^2SO^4 destroys colour of $\overline{Ind}$.	A ppte. with $BaCl^2$. When heated on charcoal gives off violet fumes of iodine. Treated with SO^2 or salts in presence of HCl and starch gives blue colour. Iodate in the iodide detected by tartaric acid by brown colour produced, and action on starch.	A ppte. with $BaCl^2$. No ppte. with $AgNO^3$ till after dry salt has been strongly heated. Salts with H^2SO^4 evolve bromine. Bromate mixed with bromide detected by yellow colour produced on addition of tartaric acid. The bromine can be extracted from the liquid by ether.	No ppte. with $BaCl^2$. Treated with H^2SO^4 does not evolve explosive gas if free from chloric. No ppte. with $AgNO^3$ till after the dry salt has been strongly heated. Same action on $\overline{Ind}$ as chloric acid on addition of HCl. Scarcely any action if free from chloric when H^2SO^4 is used instead of HCl.
Nitric.	Chloric.	Iodic.	Bromic.	Perchloric.

REACTIONS OF SOME ACIDS NOT MENTIONED IN PRECEDING TABLES.

Acetic acid or salts give a red colour with Fe^2Cl^6, destroyed by HCl and by boiling, with formation of a precipitate, red colour of soln. is not destroyed by $HgCl^2$.

Meconic acid or salts give a red colour with Fe^2Cl^6, not destroyed by HCl, by boiling or by $HgCl^2$.

Sulphocyanic acid or salts give a red colour with Fe^2Cl^6, not destroyed by HCl or by boiling, but by $HgCl^2$.

Salicylic acid or salts give a purple colour with Fe^2Cl^6. Heated with lime evolve the peculiar odour of phenol or carbolic acid.

Carbolic acid, recognized by odour, by giving a brown colour with alcoholic Fe^2Cl^6,* by giving when heated with HNO^3, carbazotic acid which forms yellow ppte. with salts of potassium. By giving whitish ppte. with bromine water.

Hydrofluoric or salts give a ppte. with $CaCl^2$, and with $BaCl^2$, which is often not visible at first. No ppte. with $AgNO^3$. Salts of fluorine best detected by heating with H^2SO^4, when a gas is evolved, which acts on glass.

Tungstic acid in salts gives ppte. with HCl sol. in excess, giving blue colour with zinc, metatungstates give little or no ppte.

Molybdic acid in salts gives ppte. very easily sol. in excess, dark blue with zinc, salt with H^2S, brownish colour and brown ppte. on addtn. of acid. For test by phosphoric acid, see Table II.

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* Hereby distinguished from creosote, which gives dark green.

SUPPLEMENTARY TABLE.

May be used with solutions, to avoid evaporation. Also in examining salts of ammonium, some of which volatilize or are decomposed without blackening. A fresh portion of the solution should be used for each column, and thus the acids reduced to few in number. Solutions may be made neutral by addition of NH^3 and warming.

Ppte. from neutral solns. by $BaCl^2$.	Ppte. from neutral solns. by $CaCl^2$.	Ppte. from neutral solns. by $AgNO^3$.	Neutral solns give with Fe^2Cl^6.	Dry salts deflagrate on charcoal.
Ppte. insol. in HNO^3 or HCl.	Ppte. formed at once.	Ppte. insol. in dilute HNO^3.	*White Ppte.*	Nitric
Sulphuric	Insoluble in $\overline{Ac}$.	*Black.*	Phosphoric	Chloric
Ppte. is soluble in HNO^3 or HCl with effervescence.	Oxalic	Hydrosulphuric	*Blue Ppte.*	Iodic
Carbonic	Hydrofluoric	*White.*	Ferrocyanic	Bromic
Sulphurous*	Ferrocyanic	Hydrochloric	*Brown Colour.*	Perchloric
Without effervescence.	Soluble in $\overline{Ac}$.	Hydrocyanic	Ferricyanic	
Phosphoric	Carbonic	Ferrocyanic	Hydriodic	
Boracic	Phosphoric	Sulphocyanic	*Red Colour.*	
Oxalic	Boracic	*Yellowish.*	Acetic	
Hydrofluoric	Tartaric	Hydriodic	Sulphocyanic	
Tartaric	Arsenious	Hydrobromic		
Citric	Arsenic	*Brownish.*		
Chromic	Ppte. formed after boiling,	Ferricyanic		
Arsenious	Citric	Ppte. sol. in dilute HNO^3.		
Arsenic		*White.*		
		Carbonic Boracic Oxalic Tartaric Citric		
		Yellow.		
		Phosphoric Arsenious		
		Red Brown.		
		Chromic Arsenic		

* The dry salt will exhibit effervescence, and also the ppte. if freed from water; but as SO^2 is easily sol. in H^2O, other tests, such as smell, and action on iodic starch paper, had better be relied on.

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